Name _____ Period _____

Genetics Problem Packet – AP Biology

Complete all work on separate paper, numbering problems accordingly.

Part 1 – Basic Patterns of Inheritance

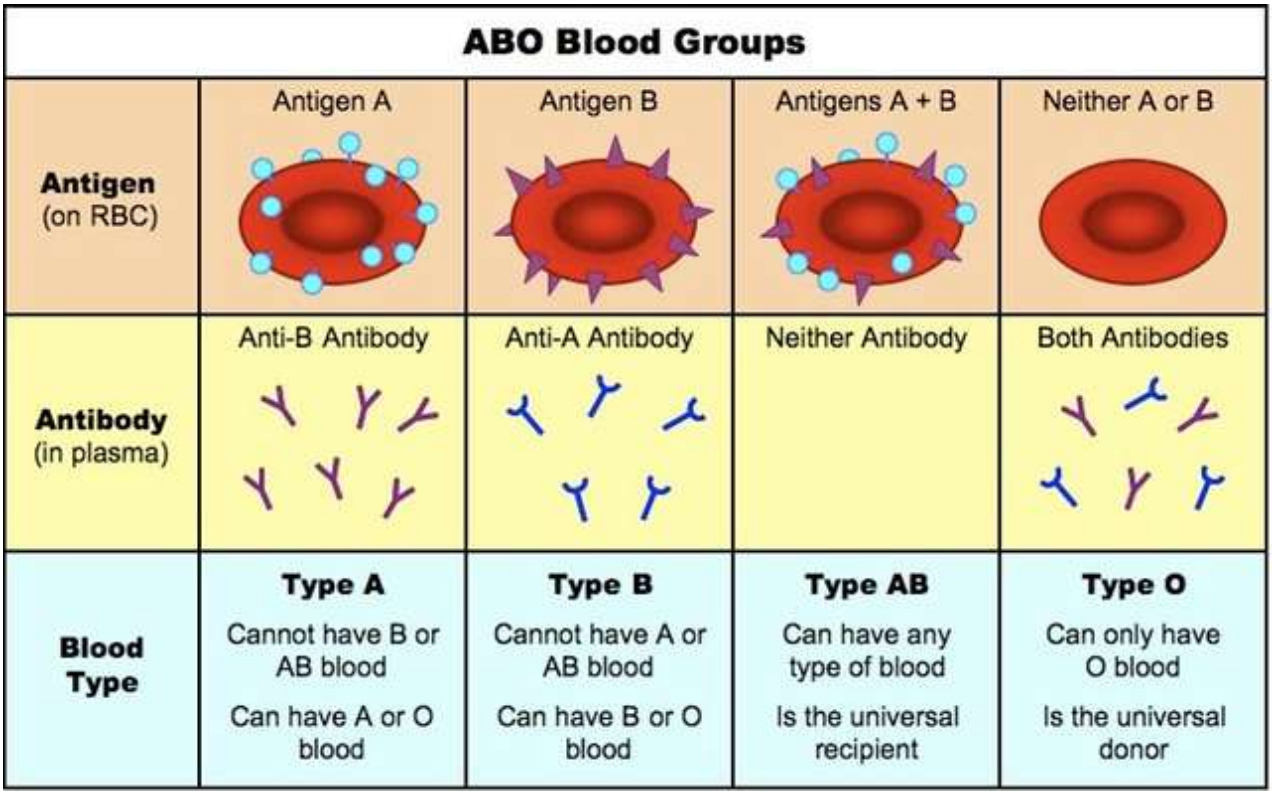
1. Two green pea plants are crossed and produce 63 green plants and 21 yellow plants. Two green F1 plants are crossed and produce an F2 generation with 44 green plants and 46 yellow plants.
    a. Explain which allele is dominant & which is recessive.
    b. Diagram the crosses to show what the P generation genotypes were.
    c. Diagram the crosses to show what the F1 generation genotypes were.
    d. Diagram the crosses to show what the F2 generation genotypes were.
    e. Explain how both of these crosses model the law of segregation.

2. A true-breeding gray fly is crossed with a true-breeding black fly and produce 1,264 gray offspring. A scientist wants to determine the genotype of a gray fly from a separate lineage.
    a. Explain which allele is dominant & which is recessive.
    b. Diagram the P-cross to show what the P & F1 generation's genotypes were.
    c. Describe how they can determine the unknown fly's genotype using a testcross, and show the cross.
    d. Describe a second cross they could perform (using only the flies mentioned in the problem) that would also determine the unknown fly's genotype, and show the cross.

3. In morning-glory plants, there are 2 alleles for flower color, yellow & blue. A yellow plant is crossed with another yellow plant and 17 yellow plants are produced. A blue plant is crossed with another blue plant and 22 blue plants are produced. A blue plant is crossed with a yellow plant and 19 green plants are produced.
    a. Explain the type of inheritance pattern in morning-glory flower color.
    b. Diagram the cross between 2 green plants and write the correct genotypic & phenotypic ratios.
    c. Diagram the cross between a green plant & a blue plant and write the correct genotypic & phenotypic ratios.
    d. Diagram the cross between a green plant & a yellow plant and write the correct genotypic & phenotypic ratios.

4. A chicken with black and white spotted feathers (termed "checkered") is crossed with an all-black chicken and produces 8 checkered & 7 black chicks. A checkered chicken is crossed with an all-white chicken and produces 9 checkered & 10 white chicks.
    a. Explain the type of inheritance pattern in chicken feather color.
    b. Diagram the cross between the checkered & black chicken, and write the correct genotypic & phenotypic ratios.
    c. Diagram the cross between the checkered & white chicken, and write the correct genotypic & phenotypic ratios.
    d. If a farmer wants to maintain mostly checkered chickens, how should they go about breeding chickens over a few years?

5. The diagram below shows the logistics of ABO blood groups. Review the diagram and explain the following:
    a. Why can't a person with type "A" blood receive blood from a "B" or "AB" donor?
    b. Why can a person with type "AB" blood receive blood from any donor?
    c. Why can a person with type "O" blood only receive blood from an "O" donor?



6. The blood type phenotypes & genotypes are shown below with their proper allelic notations.

Genotype	I^AI^A	I^Ai	I^BI^B	I^Bi	I^AI^B	ii
Phenotype f	A blood	A blood	B blood	B blood	AB blood	O blood

    a. A person with A blood and a person with B blood have children. 1 child has A blood, 1 child has B blood, 1 child has O blood and 1 child has AB blood. Diagram this cross to show the proper genotypes of the parents & children.
    b. One of their children (call it X) has its own children with a person of AB blood. 2 of their children have A blood and their other 2 children have B blood. Diagram the cross to show what the genotype of X was.

Typical 2-trait (dihybrid) cross example:

A true-breeding gray fly with normal wings is crossed with a true-breeding black fly with mutant wings. All of the F1 offspring are gray with normal wings. Show the cross between two F1 flies & write the correct genotypic & phenotypic ratios.

- We know that gray and normal wings are dominant since only they show up in the F1 generation.
- We also know the genotypes of the P-generation flies
- Parent cross = GGNN x ggnn
- Next we can model their cross in a Punnett square by writing their gamete combinations
    - GGNN parent can only have gametes of type GN
    - Ggnn parent can only have gametes of type gn
    - We place the possible gametes of each parent into a Punnett square.
    - Finally we combine the parent's gametes to model fertilization possibilities.

	GN (dominant parent's only possible gamete)
gn (recessive parent's only possible gamete)	GgNn (only possible offspring genotype)

- Next we are to cross two F1 flies, so we must first determine their possible gametes.
- Each F1 fly has the same genotype (GgNn) as shown from the first Punnett square.
- Now there are 2 types of each allele (dominant G/recessive g & dominant N/recessive n)
- The rule to remember is that meiosis ensures that each gamete will have 1 copy of each allele for every trait. So each gamete needs a body color allele (G or g) AND a wing allele (N or n).
- The possible ways for the alleles to combine are GN or Gn or gN or gn.
- Now we have 4 possible gametes for EACH F1 fly (remember both F1 flies have the same genotype) so our Punnett square must be set up as below:

	GN	Gn	gN	gn
GN				
Gn				
gN				
gn				

- We then combine each gamete from the horizontal row with each gamete from the vertical columns. Two are completed for you, fill in the remaining boxes. For reference, alleles of 1 trait are always written together and the capital letters are always written before lowercase letters.
- Write the correct genotypic & phenotypic ratios using the completed Punnett square.

	GN	Gn	gN	gn
GN				
Gn	GGNn			
gN				
gn			ggNn	

7. A true-breeding red, tall plant was crossed with a true-breeding white, short plant and all the F1 offspring were red, tall plants. Show the Punnett square & genotypic/phenotypic frequencies for the following crosses:
    a. Two F1 plants
    b. An F1 plant test-crossed to a homozygous recessive plant

8. For the data in the table below, diagram out each **parental cross** (purple x white, Inflated x constricted, & Purple, inflated x White, constricted) & **Testcross** (purple x white, Inflated x constricted, & Purple, inflated x White, constricted) with Punnett squares. Write out the genotypic & phenotypic ratios of each.

Table I shows the results of breeding experiments to examine the inheritance of flower color (purple versus white) and pod shape (inflated versus constricted). For the crosses recorded in Table I, true-breeding parents were crossed to produce F_1 offspring, which were then testcrossed to homozygous recessive individuals.

TABLE I: RESULTS FROM CROSSES WITH PEA PLANTS

Parental Cross	Phenotypes of F_1 Offspring	Phenotypes of Testcross Offspring (numbers of individuals)			
Purple × White	Purple	Purple (461)		White (468)	
Inflated × Constricted	Inflated	Inflated (593)		Constricted (588)	
Purple, Inflated × White, Constricted	Purple, Inflated	Purple, Inflated (315)	Purple, Constricted (312)	White, Inflated (320)	White, Constricted (317)

Part 2 – Complex Patterns of Inheritance

1. Colorblindness is an X-linked recessive disorder. A normal vision female and a normal vision male have children and one son exhibits colorblindness. The colorblind son has children with a normal vision female. They have a colorblind daughter & son and then a normal vision daughter & son.
    a. Diagram the crosses to show what the P generation genotypes were.
    b. Diagram the crosses to show what the F1 generation genotypes were.
    c. Diagram the crosses to show what the F2 generation genotypes were.

2. The fur color gene in cats is on the X chromosome. A black female and an orange male have four kittens. Two kittens are males with black fur and the other two kittens are females with calico fur (**black & orange fur**).
    a. Diagram the crosses to show what the P generation genotypes were.
    b. Diagram the crosses to show what the F1 generation genotypes were.
    c. Explain the other inheritance pattern in this problem (besides X-linked).
    d. If someone wanted to adopt a male calico cat, explain how the breeder should respond that describes the correct details of cat fur color inheritance.

3. For the table shown in #8 of part 1, describe how the results would need to be different to evidence that the flower color & pod shape are linked genes.

Part 3 – Mathematical Model Problems

1. In pea plants, the following are dominant alleles: green seeds, tall height, axial flower position & purple flowers. The recessive alleles are: yellow seeds, short height, terminal flower position & white flowers. The following cross was performed: GgttAaPp x GgTtaaPP, assume these genes are located on different chromosomes.
    a. What is the probability the offspring will have green seeds and short height?
    b. What is the probability the offspring will have axial flower position or tall height?
    c. What is the probability the offspring will have white flowers?
    d. What is the probability the offspring will have purple flowers or green seeds?
    **Note, if a single probability reaches 1 (100%) in an "Or" problem, the probability is just 1.

2. A woman has the genotype AabbXX and has children with a man of genotype AaBbXY. Assume all genes are on different chromosomes.
    a. What is the probability the offspring will be a male and be heterozygous for the other two traits?
    b. What is the probability the offspring will be a female and express the dominant phenotype for both of the other two traits?
    c. What is the probability the offspring will be recessive for either autosomal trait and be male?

3. In an initial cross a dihybrid purple, spiny snake is testcrossed with a white, smooth snake & produces the offspring in the table below. In a second cross a dihybrid purple, green-eye snake is testcrossed with a white, red-eye snake & produces the offspring in the table below.

a. Calculate the distance between the body color gene & the spine gene.
b. Calculate the Chi square value for the hypothesis that the body color gene & the spine gene assort independently.
c. Accept or Reject the hypothesis and explain what your decision means.
d. Calculate the distance between the body color gene & the eye color gene.
e. Calculate the Chi square value for the hypothesis that the body color gene & the eye color gene assort independently.
f. Accept or Reject the hypothesis and explain what your decision means.
g. Construct a gene map showing the distance between any linked genes.

731 Purple, Spiny	698 White, Smooth	62 Purple, Smooth	53 White, Spiny
397 White, Red Eyes	246 White, Green Eyes	402 Purple, Green Eyes	218 Purple, Red Eyes

4. In an initial cross a dihybrid gray, long-tail mouse is testcrossed with a white, short-tail mouse & produces the offspring in the table below. In a second cross a dihybrid long-tail, blue-eye mouse is testcrossed with a short-tail, red-eye mouse & produces the offspring in the table below.

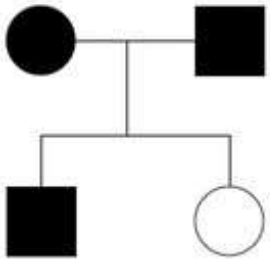
a. Calculate the distance between the body color gene & the tail gene.
b. Calculate the Chi square value for the hypothesis that the body color gene & the tail gene assort independently.
c. Accept or Reject the hypothesis and explain what your decision means.
d. Calculate the distance between the tail gene & the eye color gene.
e. Calculate the Chi square value for the hypothesis that the tail gene & the eye color gene assort independently.
f. Accept or Reject the hypothesis and explain what your decision means.
g. Construct a gene map showing the distance between any linked genes.

631 White, Short Tail	692 Gray, Long Tail	52 White, Long Tail	56 Gray, Short Tail
409 Short Tail, Red Eyes	298 Short Tail, Blue Eyes	301 Long Tail, Red Eyes	416 Long Tail, Blue Eyes

5. Two genes are linked and located 31 m.u. apart. If there were 1104 parental type offspring from a dihybrid x double recessive (testcross), what was the total number of offspring from the testcross?

Part 4 - Pedigree Analysis

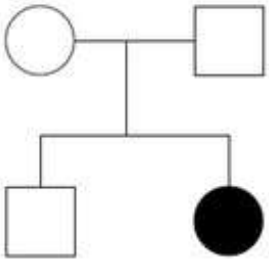
The image below shows how 4 typical pedigrees appear. Circles are females, squares are males. Shaded individuals are affected/have the phenotype/disorder but unshaded individuals are unaffected/don't show the phenotype. The generations go from top (older generations) to bottom (younger generations). Siblings are all connected by the same parental lineage.



Autosomal Dominant

Cannot be recessive as affected parents could not have an unaffected offspring

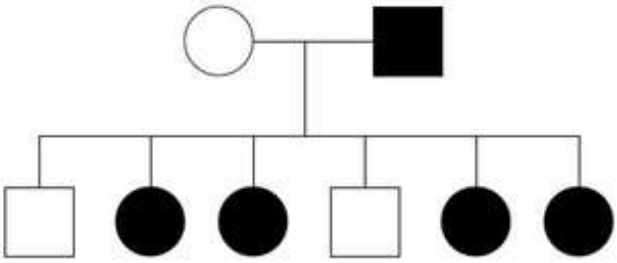
Parents MUST be heterozygous



Autosomal Recessive

Cannot be dominant as unaffected parents could not have an affected offspring

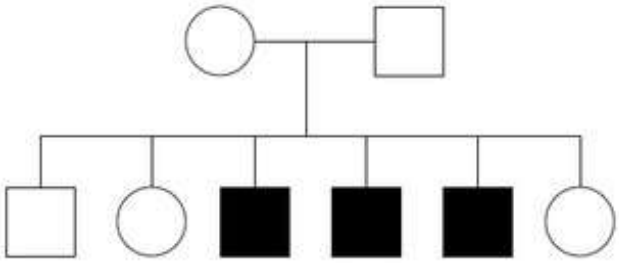
Parents MUST be heterozygous



X-Linked Dominant

Mode of inheritance cannot be confirmed

However, 100% incidence of affected daughters from an affected father suggests X-linked dominant inheritance



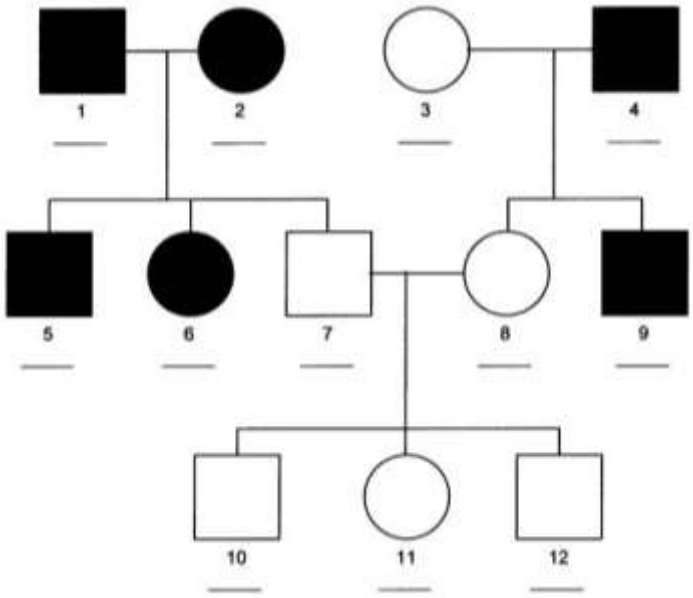
X-Linked Recessive

Sex linkage cannot be confirmed

However, high incidence of affected sons suggests X-linked recessive inheritance

For each pedigree, identify the mode of inheritance & all genotypes possible. For X-linked pedigrees, use X's & Y's with superscripts for the genotypes. For autosomal, use any letter of your choice.

1.



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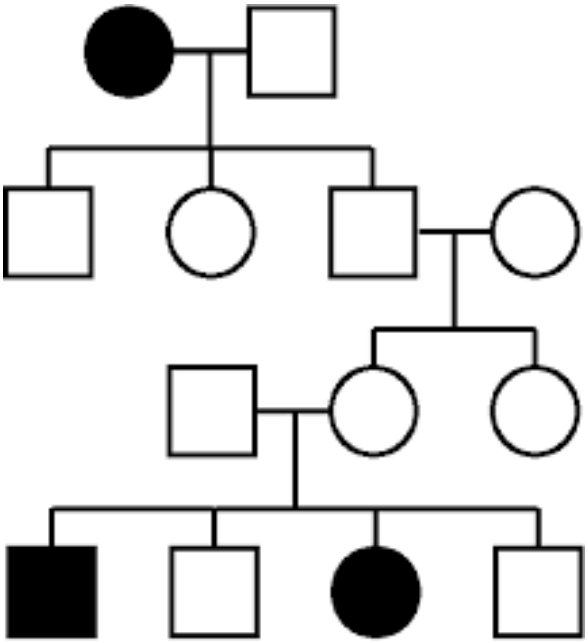

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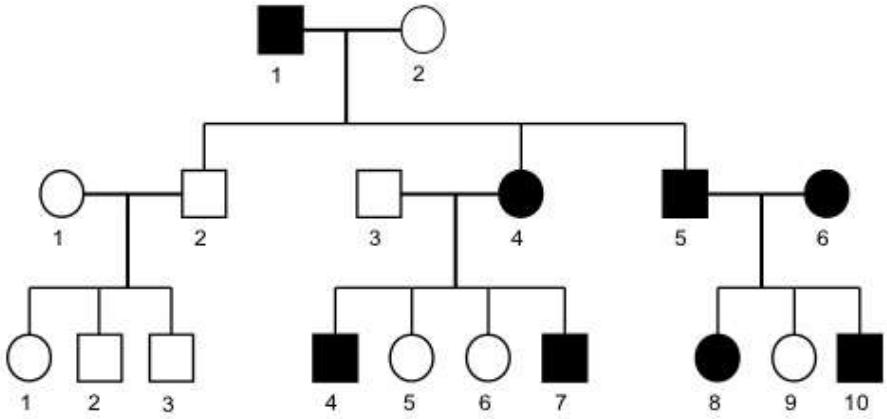

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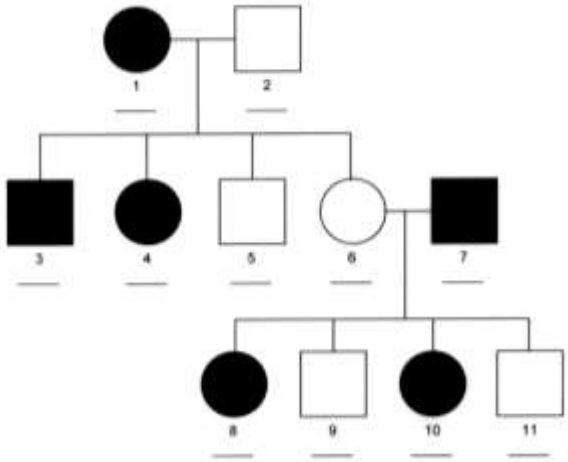

5.